

"Made available under NASA sponsorship  
in the interest of early and wide dis-  
semination of Earth Resources Survey  
Program information and without liability  
for any use made thereof."

E7.4-10684

CR-139251

Detection of Moisture and Moisture Related  
Phenomena from Skylab

Joe R. Eagleman  
Principal Investigator

(E74-10684) DETECTION OF MOISTURE AND  
MOISTURE RELATED PHENOMENA FROM SKYLAB  
Monthly Progress Report, Jul. 1974  
(Kansas Univ. Center for Research, Inc.)  
17 p HC \$4.00

N74-30676

CSCL 08H

G3/13

Unclas  
00684

Monthly Progress Report, July, 1974

Atmospheric Science Laboratory  
Center For Research, Inc.  
University of Kansas

Detection of Moisture and Moisture Related  
Phenomena from Skylab

Joe R. Eagleman  
Principal Investigator

Norman Hardy and Surendra Parashar  
Graduate Research Assistants

Atmospheric Science Laboratory  
Space Technology Center  
Center for Research, Inc.  
University of Kansas in  
Lawrence, Kansas 66045

Clayton D. Forbes, Technical Monitor  
Principal Investigations  
Management Office  
Lyndon B. Johnson Space Center  
Houston, Texas 77058

EREP NO.540-A2 March 19, 1973 to August 31, 1974




Contract Number NAS 9-13273

## COMPENSATIONS OF RADIOMETRIC DATA FOR CLOUD COVER

An attempt is being made to compensate the radiometric antenna temperature as measured by S193 for the areas where cloud cover occurred. It was shown by Wu (1973) that the effect of cloud cover depends on the density and the type of the cloud. An analysis of the amount and type of clouds over the individual S193 footprints has been completed for the June 5 pass over Texas, Figure 1, as described in the May progress report. Cloud cover varied from none to almost 100% heavy cloud cover as extracted from the S190A photography. The influence of cloud cover on the S194 radiometric temperatures are probably negligible, but should slightly increase the correlation of the S193 data with soil moisture content. For the cases where cloud cover exists, corrections can be made by modification to developed methodology, Wu (1973) or by the techniques described by Benoit (1968).

## EFFECT OF ANTENNA PATTERN

An attempt is being made to find the effect of antenna pattern of S194 L-band radiometer on the antenna temperature measurement. The S194 sensor has a  $15^{\circ}$  half-power beam width. This implies that 50% of the energy received by the antenna will be received in the  $15^{\circ}$  solid pyramid centered about the vertical axis. The antenna

 OPEN WATER  
 LIGHT CLOUDS  
 HEAVY CLOUDS

TEXAS SITE S-193 6/5/73

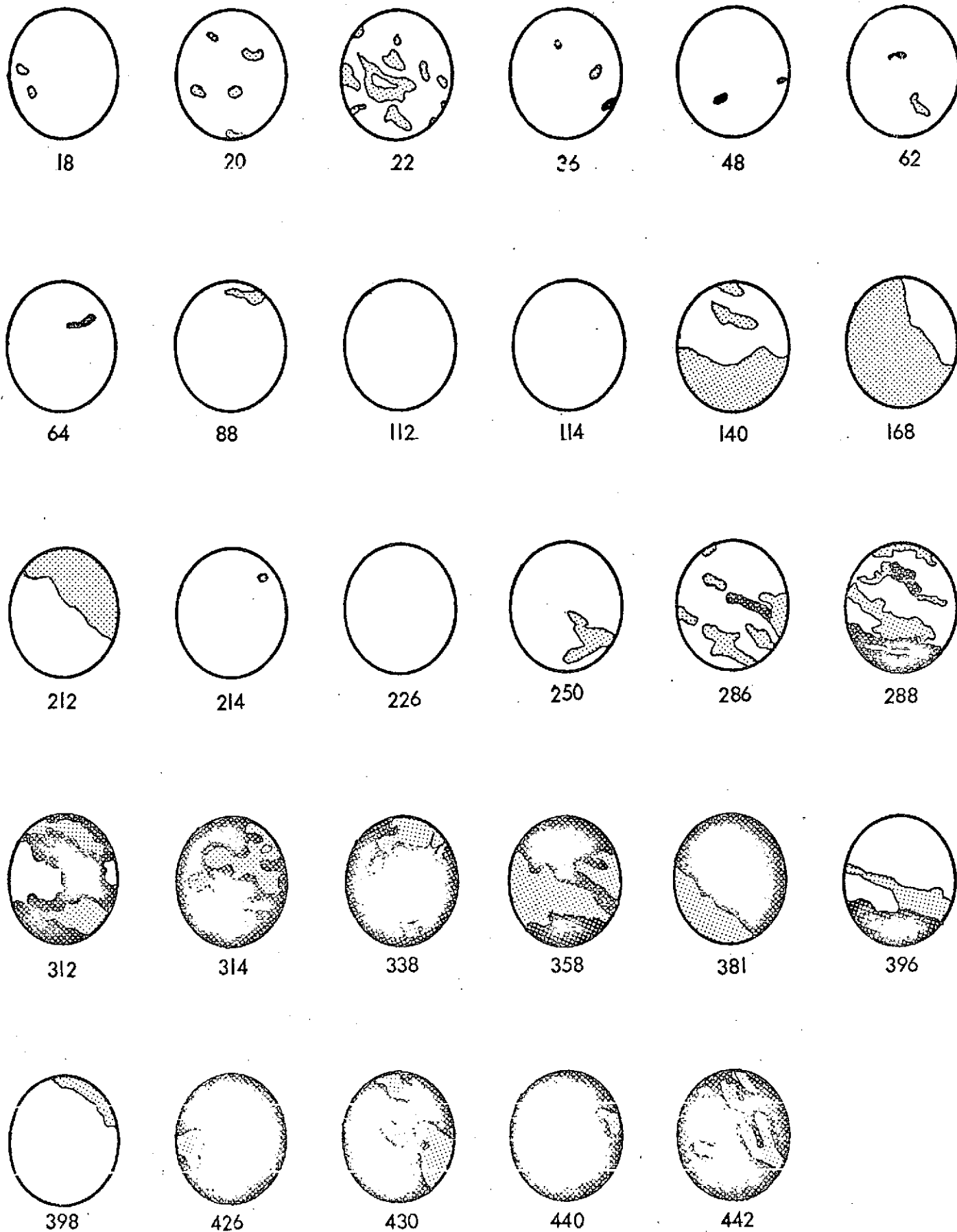


Figure 1

will receive over 90% of the energy available in the field of view in a  $36^\circ$  solid pyramid. Both of these angles are contained in the primary lobe of the antenna. The  $36^\circ$  angle will encompass a swath width of approximately 144 nmi at the 234 nmi orbital altitude. The radiometer antenna temperature recorded by the sensor will be influenced to a greater extent by the brightness of the material contained within the  $15^\circ$  beam width.

The sampling of the radiant energy received by the antenna was done at a rate to ensure a minimum of 97% ground coverage overlap. The distance on the ground between the centers of two consecutive resolution cells is about 2 nmi. Because of such a small distance, the difference in the radiometric antenna temperature between two consecutive cells may be due to random fluctuations due to noise rather than to any changes in ground emission. Thus, for a meaningful analysis, it is important to establish the effect of antenna pattern to show at what distance ground effects begin to predominate over those of the noise.

An attempt is being made to find out what type of ground variation, as a function of time, is required to produce the radiometric data. If  $g(t)$  is the ground temperature as a function of time (i.e. surface brightness temperature as a function of distance or time),  $a(t)$ , the antenna pattern as a function of time, and  $w(t)$  as some

type of window function or distorting factor, then the data  $d(t)$  (radiometric measurement as a function of time) is given by:

$$d(t) = a(t) * [g(t)w(t)]$$

where  $*$  implies convolution. Taking the Fourier transform of above we find:

$$D(f) = A(f) [G(f) * W(f)]$$

$$G(f) * W(f) = H(f) = D(f)/A(f)$$

where  $g(t)$  is the inverse Fourier transform of  $G(f)$ . An attempt shall be made to see if it is possible to obtain a better  $g(t)$  for S194 radiometer by suitable choice of  $w(t)$ . A similar attempt shall be made in finding the effect of S193 antenna pattern.

#### VEGETATION AND LAND USE

In order to understand the contribution of vegetation to Skylab measurements, recent research has also been directed toward the preparation of a vegetation, land-use type map of the western Texas site. This map is being prepared from the S190A and S190B vertical color photography and from ground truth photographs taken during the soil moisture sampling missions. To date, only the map representing the June 5, 1973 test area has been completed (Figure 2). Table I describes in some detail vegetation characteristics of each category on the map.

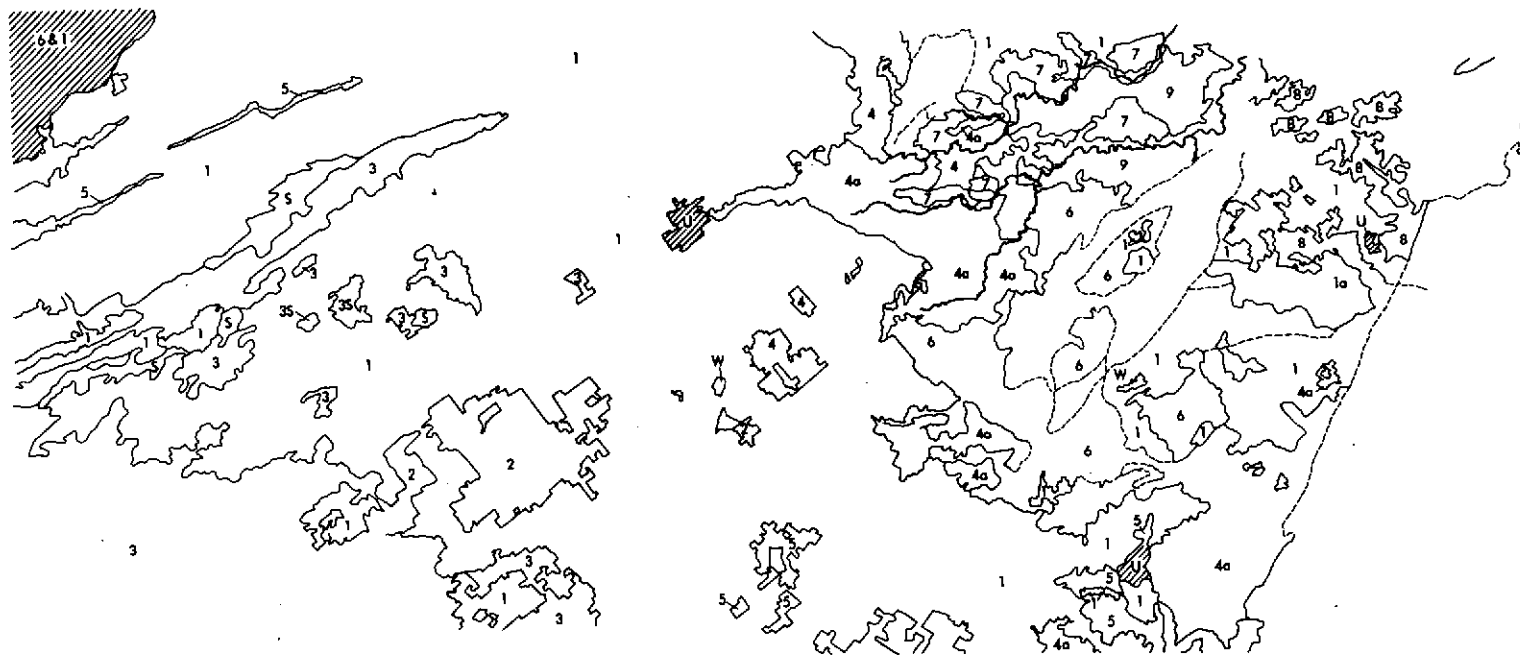


Figure 2 . Vegetation type map of the June 5, 1973 Texas test site. Numbers refer to map categories and are referenced to Table .

TABLE I

Texas Test Site  
(June 1973)

Vegetation-Land Use

Map Category	UNESCO Formula	Description
1	V-D-2b	Dominantly bare ground, some emergent shoots of cotton and grain sorghum less than 5 cm in height.
1a	V-D-2b	Same as above; variations due to soil type differences.
2	V-C-3c	Short grassland; dominant graminoid growth forms are less than 50 cm tall. Woody synusia of shrubs covering less than 10% of the area.
3	V-C-6a	Short grass communities practically without woody synusia.
4	V-B-3c	Medium tall grassland; dominant graminoid growth forms are 50 cm to 2 m tall; woody synusia of broad leaf deciduous shrubs covering 10% or less.
4a	V-B-3c(1)	Same as above, but total plant coverage per unit area is significantly less.
5	V-D-2b(2)	Mainly anual low forb communities less than 1 m tall.
6	V-B-3c(2)	Medium tall grassland; dominant graminoid growth forms are 50 cm to 2 m tall; woody synusia of broad leaf deciduous shrubs covering 10-40%
7	III-C-2a	Xeromorphic (sub-desert) shrubland without succulents. Open stands of shrubs with various xerophytic adaptations. Mainly less than 2 meters tall.



TABLE I (cont.)

Map Category	UNESCO Formula	Description
8	III-B-3a(1)	Temperate deciduous shrubland. Moderately dense scrub with more or less continuous grass under story. Shrubs 2 to 3 m. tall. Grass less than 50 cm tall.
9	III-B-3a(2)	Temperate deciduous shrubland. Essentially the same as category 8, but the percentage of shrub coverage is lower and individual plants are more widely separated.
9a	III-B-3a(3)	Same as above, but much less total vegetative cover, i.e., more bare soil.
S		Bare saline soils, often found in dry channel or depressions.
W		Water.
U		Urban.

The vegetation of the test area is classified according to the methods established in the International Classification and Mapping of Vegetation (UNESCO, 1973). The categories used in the classification are units of vegetation, including both zonal formations and the more important and extensive azonal and modified formations. The system is based upon vegetation physiognomic rather than floristic considerations and considering the nature of the Skylab project to which it is applied, this is quite appropriate.

Supplementary terms referring to climate, soil and land-forms are included in the names and occasionally in the definitions, where they help the identification of a given unit. Although most units are defined physiognomically, they broadly indicate environmental conditions.

Considering the specific details, the classification is divided into five major categories: (i) Closed Forest, (ii) Woodland, (iii) Scrub, (iv) Dwarf-Scrub and Related Communities, (v) Herbaceous Vegetation.

Figure 3 is the same map except that those S193 footprints for which soil moisture data are available have been superimposed on the land-use, vegetation categories. The relative amounts of each vegetation type within each footprint are given in Table II. The percentage of each type of vegetation within each footprint was determined by utilizing a Hewlett-Packard calculator-digitizer system. This simply involves entering a numerical integration

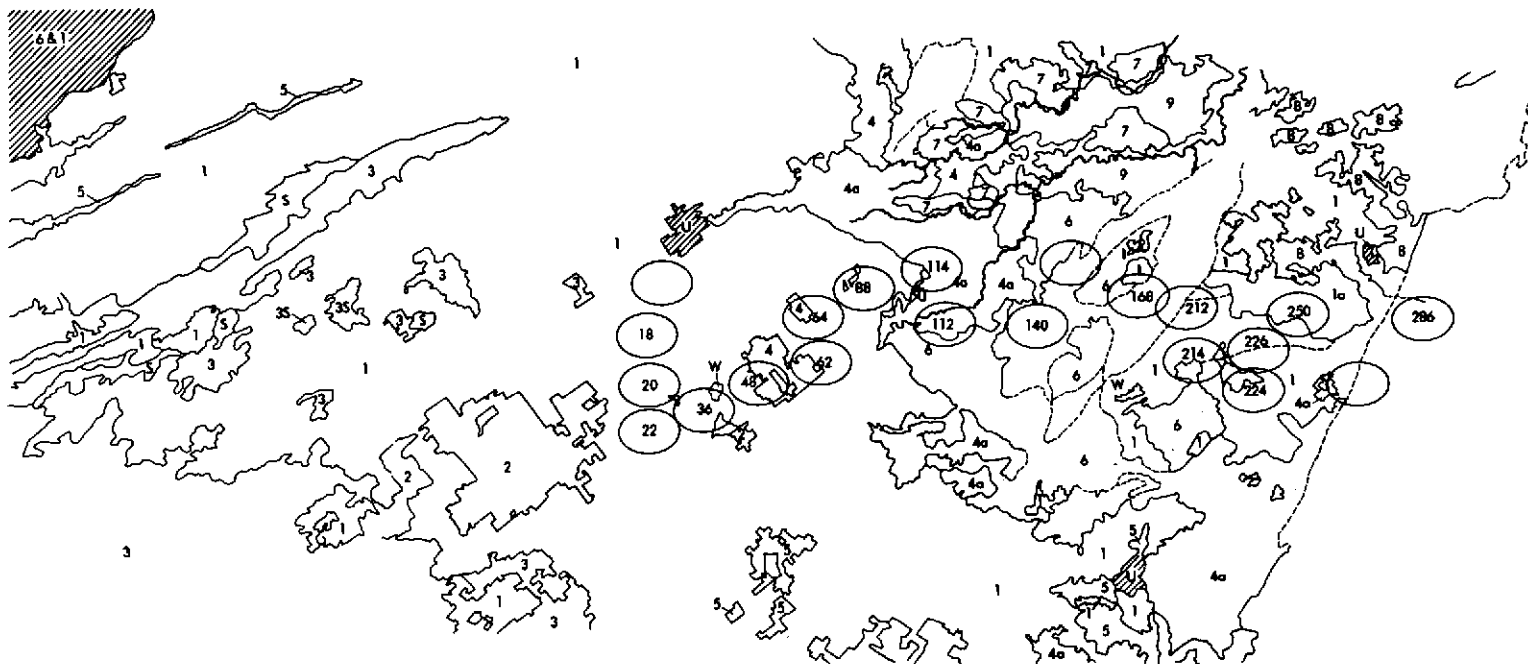


Figure 3 . Vegetation type map of the June 5, 1973 Texas test site showing the relative position of the S193 footprints for which soil moisture information is available. The footprint numbers correspond to those of Table 1 .

TABLE II

Footprint Number	Map Category	Percent Coverage
18	1	100
20	1	100
22	1	100
36	S	4
	W	8.2
	1	87.8
48	1	48.6
	4	51.4
62	1	29.1
	4	70.9
64	1	82.2
	4	17.8
88	1	96.4
	4	3.6
112	4a	60.2
	6	39.8
114	1	20.7
	4a	68.7
	6	10.6
140	6	11.9
	cloud	88.1
168	1	7.5
	6	19.6
	cloud	72.9
212	1	30.2
	cloud	69.8
214	1	11.2
	6	88.2
226	1	88.0
	1a	12.0
250	1	86.4
	1a	13.6
286	1	23.9
	8	76.1

program into the programable calculator which allows continuous sampling by the digitizer. Digitizing is done on a sensitive surface in order that continuous coordinates can be read off and fed into the calculator. When the digitizer is returned to the starting point, a display appears which represents the enclosed area. This is then readily convertible to square miles, kilometers or any appropriate aerial measurement or simply to percent coverage as has been done in this case.

Since the area was classified from satellite photography, areas under heavy clouds have not been classified; therefore, the map is incomplete with respect to the total test strip. Although they are not complete at this time, similar maps are being produced for the other data sets in Texas and Kansas.

In addition to plotting the S193 footprints on these maps, S194 footprints were plotted and categorized in preparation for further analysis of the contribution of vegetation to the S194 measurements, Figure 4. The footprint was taken to be a circle of 60 nautical miles in diameter.

Table III lists the footprint numbers, categories within each footprint and percentage of each footprint occupied by each category. The key to the categories is to be found in Table I.

As in the case of the S193, not all footprints for the pass have been considered. This is due to the fact that

TABLE III

<u>Footprint Number</u>	<u>Categories Present</u>	<u>Percent Coverage</u>	<u>Footprint Number</u>	<u>Categories Present</u>	<u>Percent Coverage</u>
1	3	2.49	7	s	0.21
	3s	0.96		U	1.06
	1	82.7294		W	0.15
	2	12.93	8	1	88.1675
	s	0.26		2	5.13
	U	0.63		3	0.283
2	1	83.2419		4	2.57
	2	11.65		4a	2.39
	3	2.23		6	0.03
	3s	0.84		U	1.06
	s	0.998		s	0.21
	U'	1.05		W	0.15
3	1	83.30	9	1	86.4938
	2	11.95		2	3.56
	3	2.21		3	0.28
	3s	0.11		4	2.57
	s	0.72		4a	4.42
	4	0.49		5	0.29
	4a	0.16		6	0.96
	U	1.06		s	0.21
4	1	82.6800		U	1.06
	2	11.66		W	0.15
	3	2.21	10	1	82.8588
	s	0.49		2	2.31
	W	0.1513		3	0.283
	U	1.06		4	2.57
	4	1.47		4a	7.92
	4a	0.28		5	0.50
5	1	13.00		6	2.13
	2	10.68		s	0.21
	3	1.54		U	1.06
	4	2.57		W	0.15
	4a	0.512	11	1	77.8931
	s	0.49		2	1.50
	U	1.06		3	0.2831
	W	0.15		4	2.57
6	1	84.6419		4a	11.67
	2	9.53		5	0.76
	3	1.06		6	3.78
	4	2.57		7	0.38
	4a	0.77		U	1.06
	s	0.21		s	0.21
	U	1.06		W	0.15
	W	0.15	12	1	73.4000
7	1	87.2119		2	0.63
	2	7.00		3	0.04
	3	0.53		4	2.57
	4	2.57		4a	14.88
	4a	1.27		5	0.88

TABLE III (cont.)

<u>Footprint Number</u>	<u>Categories Present</u>	<u>Percent Coverage</u>	<u>Footprint Number</u>	<u>Categories Present</u>	<u>Percent Coverage</u>
12	6	5.80	17	1	41.4269
	7	0.38		2	2.76
	U	1.06		4	3.65
	s	0.21		4a	21.80
	W	0.15		6	21.14
13	1	65.52		7	1.50
	2	2.76		S	0.15
	4	2.57		W	0.13
	4a	17.79		C	7.43
	5	0.88	18	1	40.1644
	6	7.61		2	0.09
	7	0.57		4	3.65
	S	0.21		4a	19.92
	U	1.06		6	23.54
	W	0.15		7	1.50
	Cloud	0.88		9	20.57
14	1	60.4119		W	0.16
	2	2.76		C	10.40
	4	2.57	19	1	35.225
	4a	20.07		4	3.54
	5	0.61		4a	18.83
	6	8.79		6	26.03
	7	0.91		7	1.50
	d	0.21		9	1.60
	U	0.96		W	0.16
	W	0.15		C	13.12
	C	2.57	20	1	35.1013
15	1	59.6688		4	2.59
	2	2.76		4a	17.48
	4	2.57		6	27.00
	4a	17.33		7	1.50
	5	0.40		9	1.30
	6	11.03		W	0.16
	7	1.22		C	14.87
	S	0.21	21	1	32.3206
	U	0.25		4	1.42
	W	0.15		4a	16.10
	C	4.41		6	29.69
16	1	64.7681		7	1.50
	2	2.76		9	2.44
	4	3.65		W	0.16
	4a	21.58		C	16.37
	5	0.10	22	1	30.2006
	6	17.04		1a	0.36
	7	1.22		4	1.33
	W	0.13		4a	14.95
	S	0.21		6	32.9575
	C	6.55			

TABLE III(cont.)

<u>Footprint Number</u>	<u>Categories Present</u>	<u>Percent Coverage</u>
22	1	30.2006
	1a	0.36
	4	1.33
	4a	14.95
	6	32.5975
	7	1.25
	9	2.62
	W	0.16
	C	16.5406
23	1	28.0350
	1a	1.08
	4	0.27
	4a	14.2419
	6	33.7525
	7	0.96
	8	0.11
	W	0.16
	C	17.4475
24	1	26.7919
	1a	1.96
	4a	12.7113
	6	34.6931
	7	0.66
	8	0.82
	9	4.14
	W	0.16
	C	18.0650
25	1	24.8231
	1a	3.0825
	4a	10.1244
	6	37.1956
	8	1.87
	9	4.1481
	W	0.16
	C	18.59



the S190B data base is partially cloud covered. Further information will be filled in from other sources such as ERTS photography, however, to complete the classification.

#### REFERENCES

Benoit, Andre, "Signal Attenuation Due to Neutral Oxygen and Water Vapor, Rain and Clouds", The Microwave Journal, vol. 11, no.11, pp. 73-80, November, 1968.

International Classification and Mapping of Vegetation, UNESCO, Paris, 1973, 93pp..

Wu, Steve, "The Meteorological Effects on Microwave apparent Temperatures Looking Downward over a Smooth Sea", The University of Kansas Center for Research, Inc., Lawrence, Kansas, 1973. (NAS-CR-2325)